The Role of NIST in the Calibration of Future High Spectral Resolution Instruments

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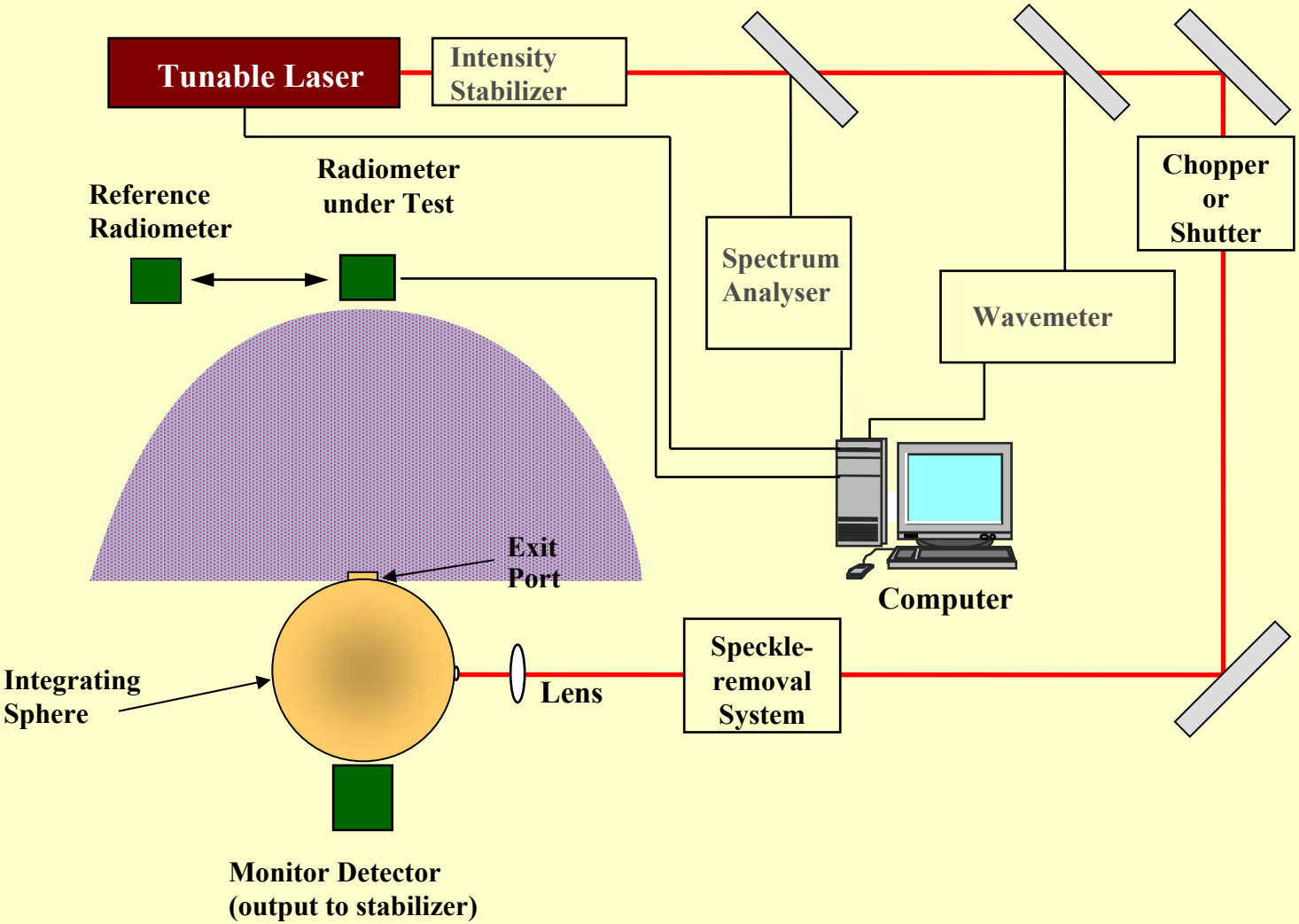
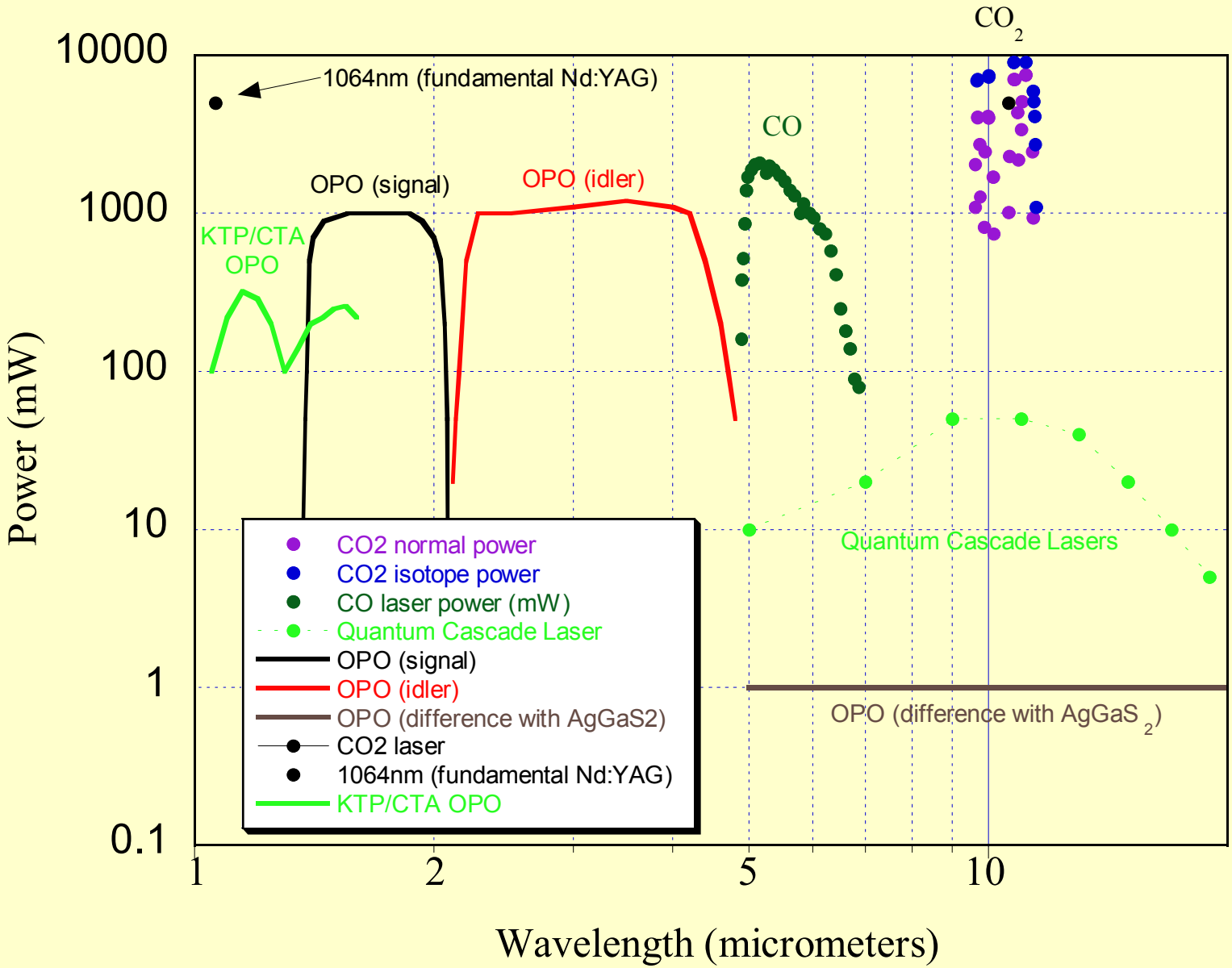
Role of NIST: Demonstrate use of Tunable Lasers in Calibration

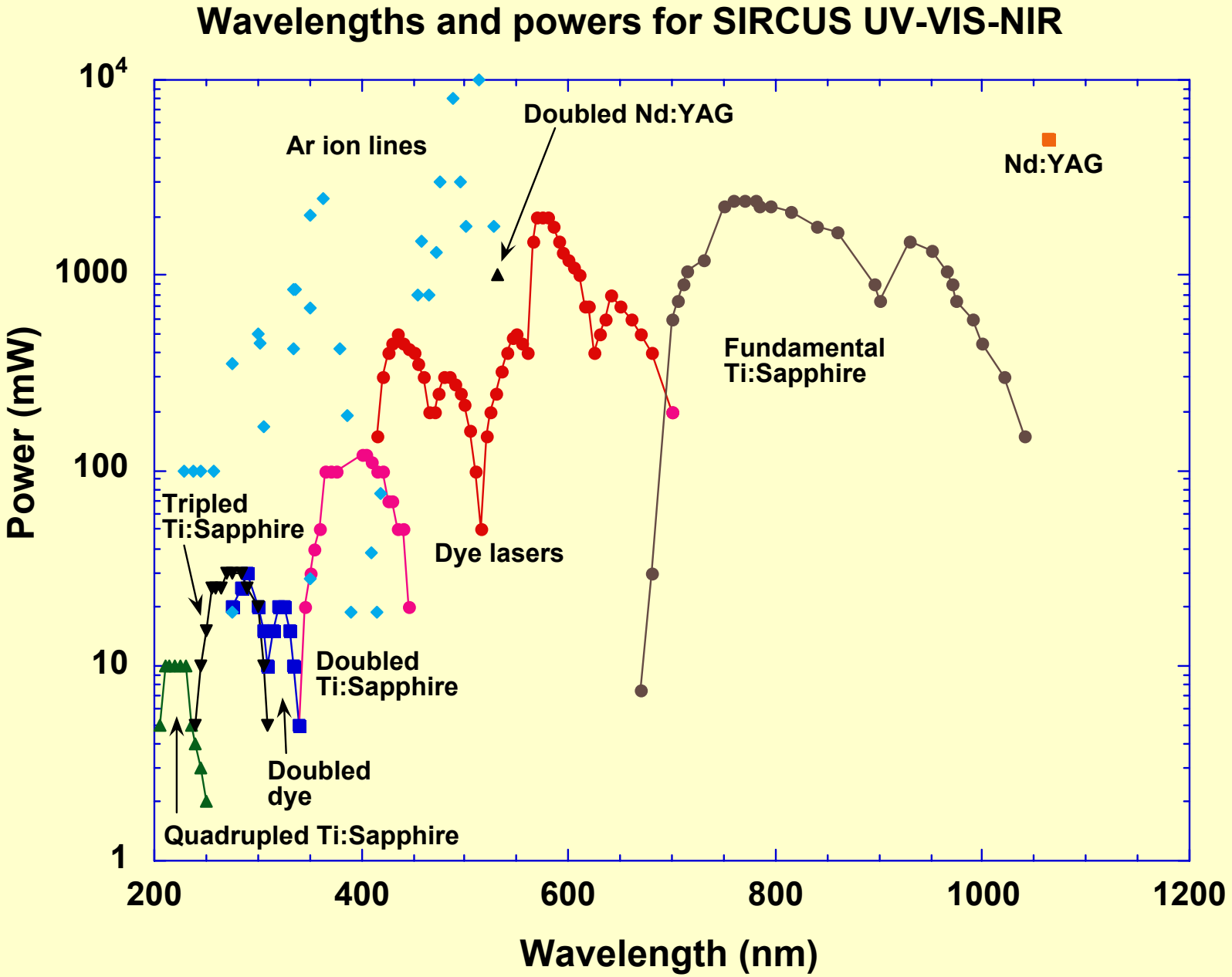
- The ideal calibration source:
  - -large-area to fill entrance optics of system
  - -easily re-configurable to become a point source
  - -spatially uniform and temporally stable
  - -monochromatic
  - -high spectral radiance or irradiance
  - -tunable across bandpass and out-of-band as well
  - -easily measured radiance or irradiance
  - -provides means to chop away thermal-infrared background
  - -can change radiance level easily to measure linearity
- This used to be impossible….
- But now, with continuously tunable lasers at 1 W levels…..

IR SIRCUS: Infrared Spectral Irradiance and Radiance Responsivity Calibrations using Uniform Sources



Lasers at IR SIRCUS

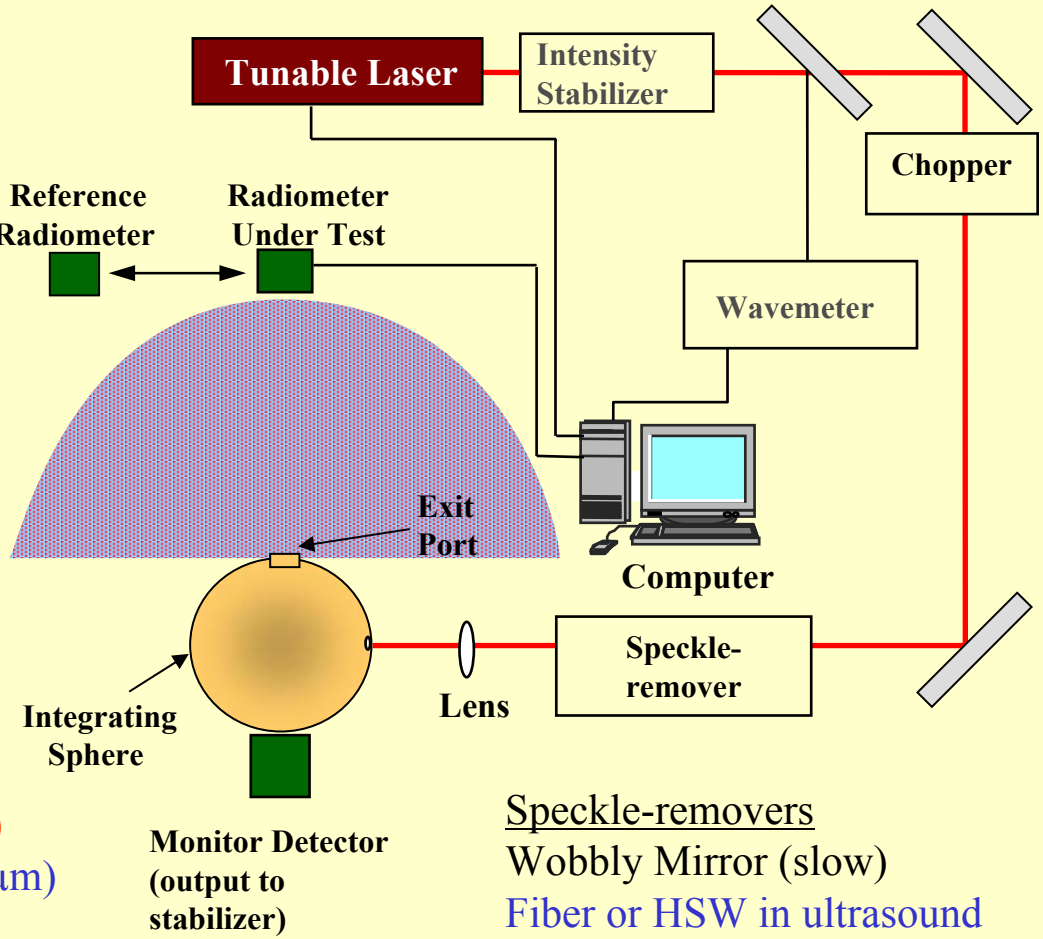



Wavelengths and powers for SIRCUS UV-VIS-NIR
Power (mW)
Wavelength (nm)
10^4
1000
100
10
1
200
400
600
800
1000
1200
Ar ion lines
Doubled Nd:YAG
Nd:YAG
Fundamental
Ti:Sapphire
Tripled
Ti:Sapphire
Dye lasers
Doubled
Ti:Sapphire
Doubled
dye
Quadrupled Ti:Sapphire

IR SIRCUS: Spectral Irradiance and Radiance Responsivity Calibrations with Uniform Sources

Wavelengths (microns)
1.064 YAG
1.4 - 4.9 OPO (continuous)
9 – 11 CO_2 (discrete 10 lines)
9-11 Isotopic CO_2 (discrete 10 lines)
4.8 - 6 CO (discrete, lots of lines)
5-12 OPO (continuous, mW)
8-12 Quantum Cascade (continuous, several)

Reference Radiometers
Electrically Substituted Bolometer (ESB)
InGaAs (working standard)
Extended InGaAs (working standard)
Germanium, InSb, MCT (working standard)



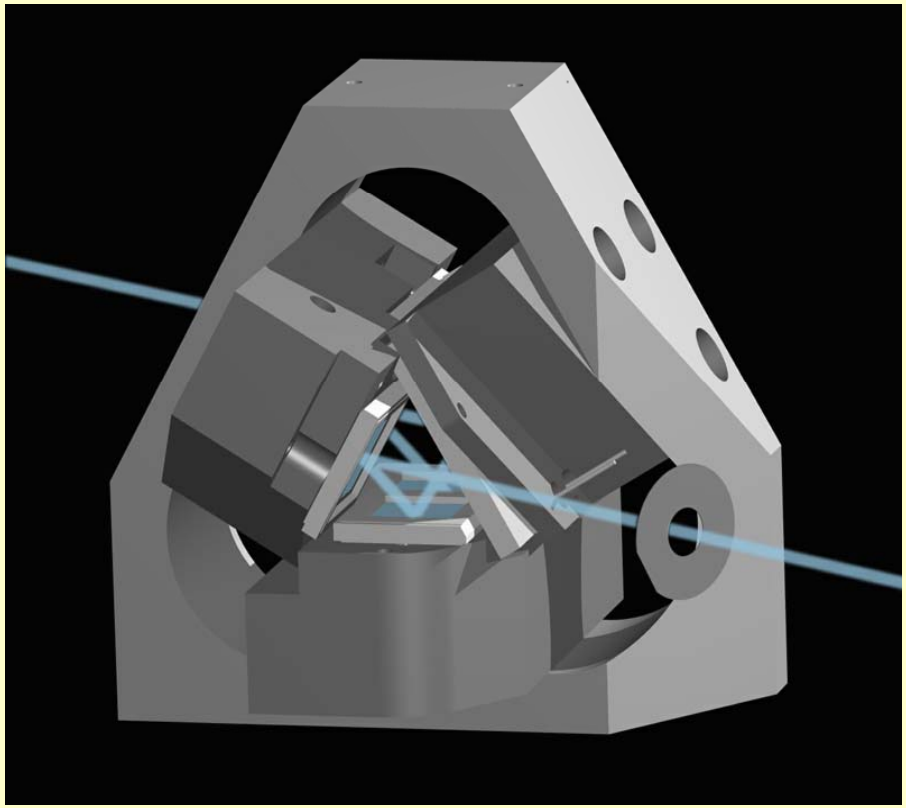
Intensity Stabilizers
Fresnel Attenuator (broadband, slow response)
EOM (medium bandwidth, fast response, 1-5 μm)
AOM (narrow bandwidth, fast response)

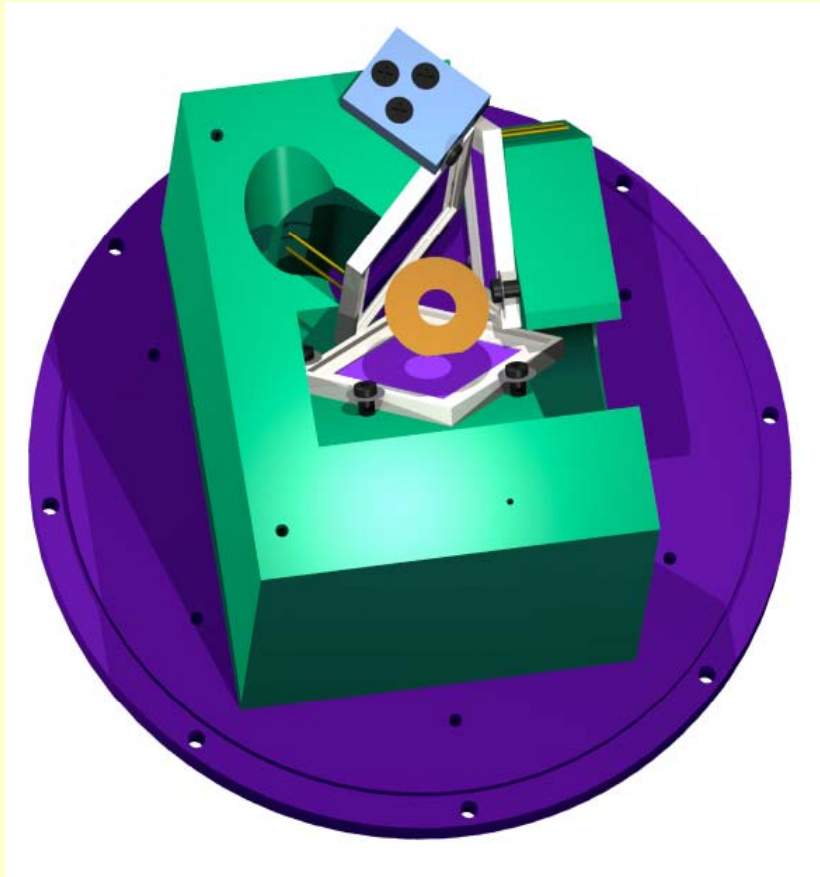
Speckle-removers
Wobbly Mirror (slow)
Fiber or HSW in ultrasound

BLUE: PROGRESS MADE IN FY03. RED: FUTURE ADDITIONS

Irradiance Traps: Reference Detectors at SIRCUS UV-VIS-NIR

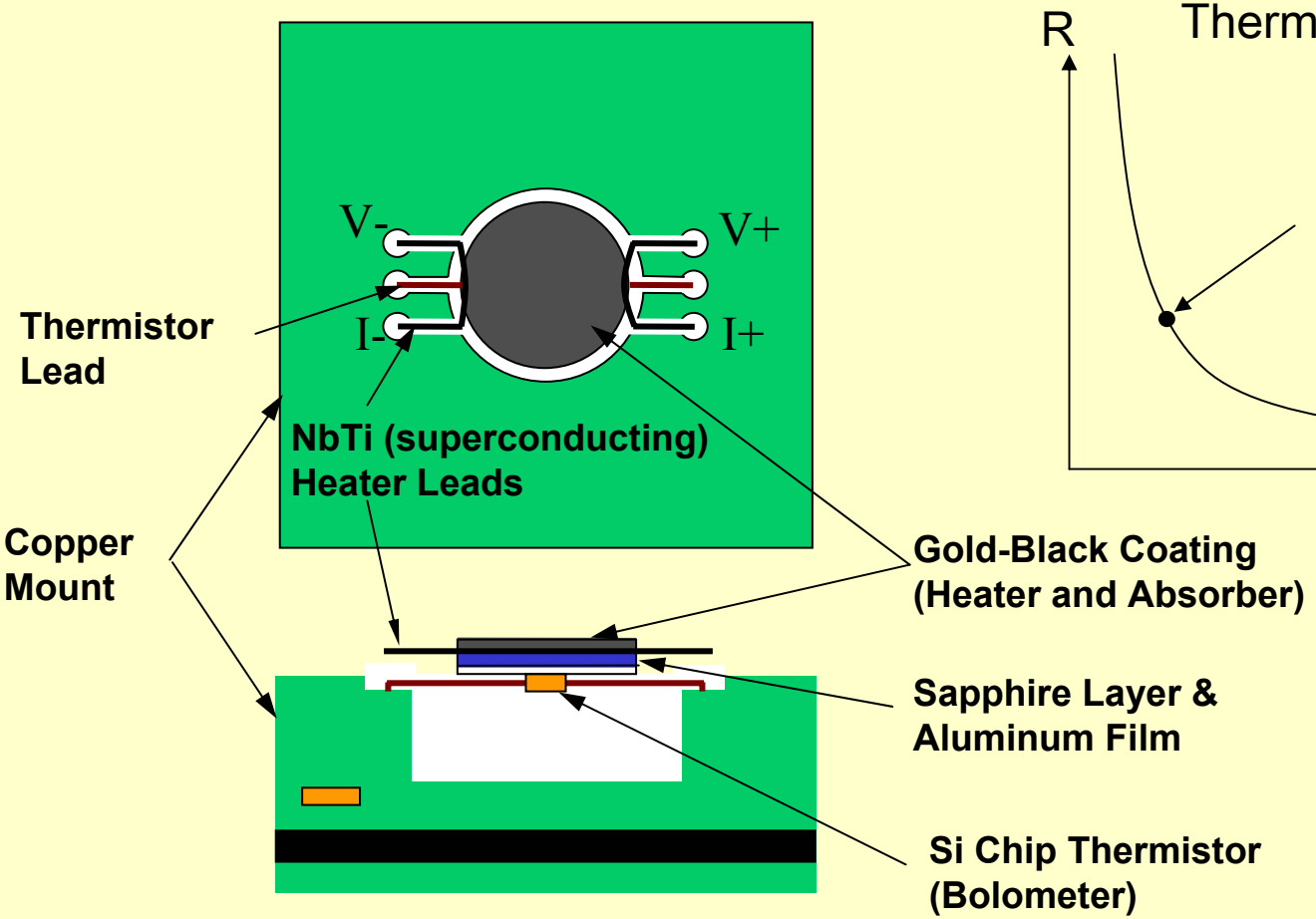
Precision aperture having measured area,
in front of a spatially-uniform Si photodiode trap having measured power responsivity.

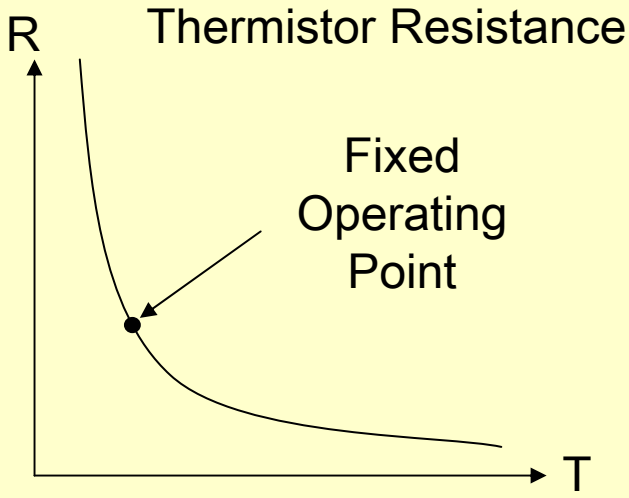


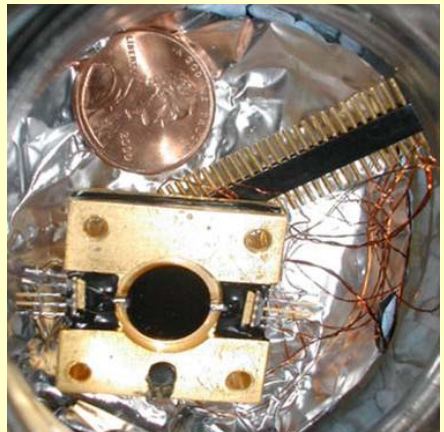


Electrically Substituted Bolometer (ESB)

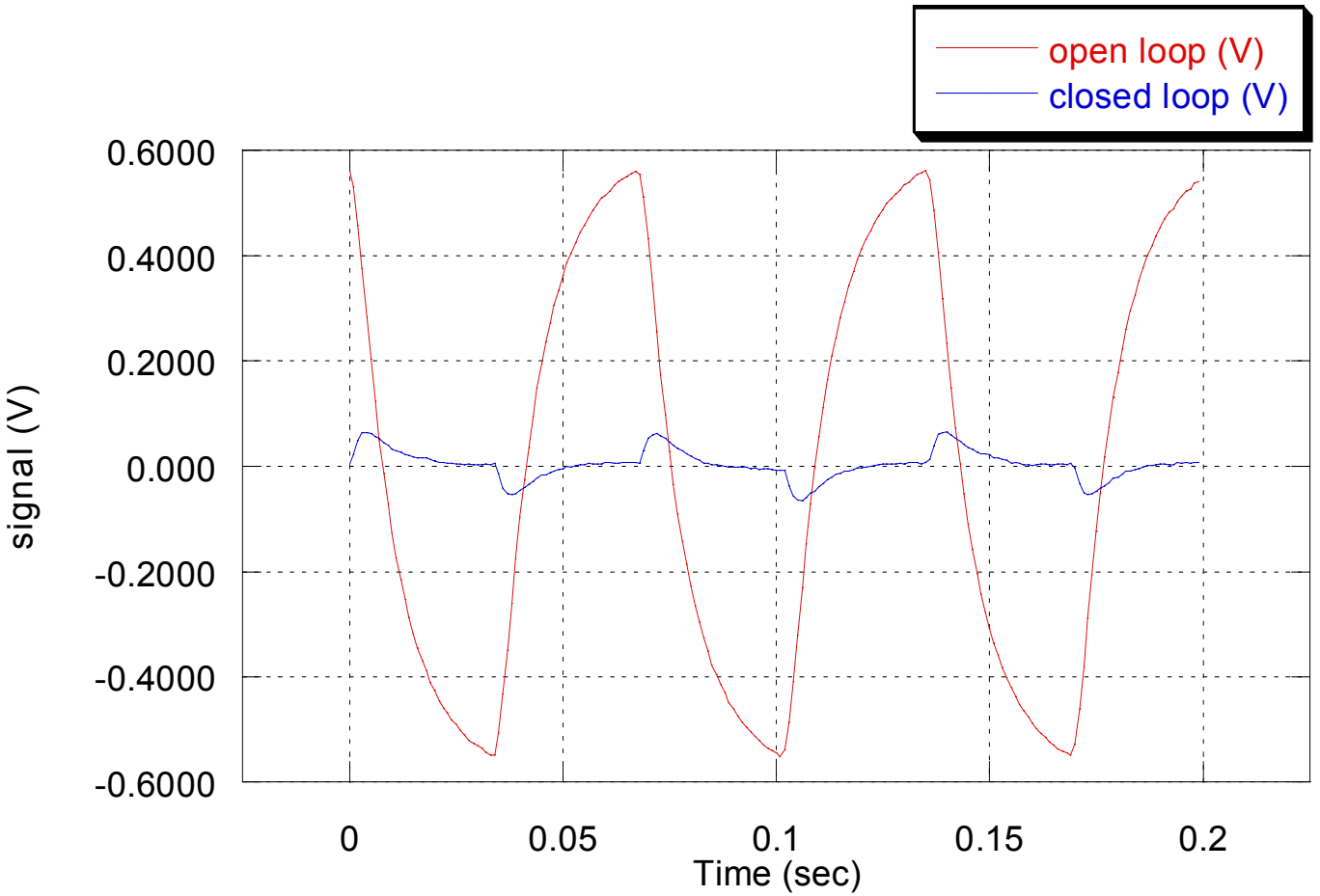
- NEP = 30 pW/Hz$^{1/2}$ @ 15 Hz for 1 cm diameter detector @ 5 Kelvin
- Similar to an IR Labs bolometer except with electrical substitution





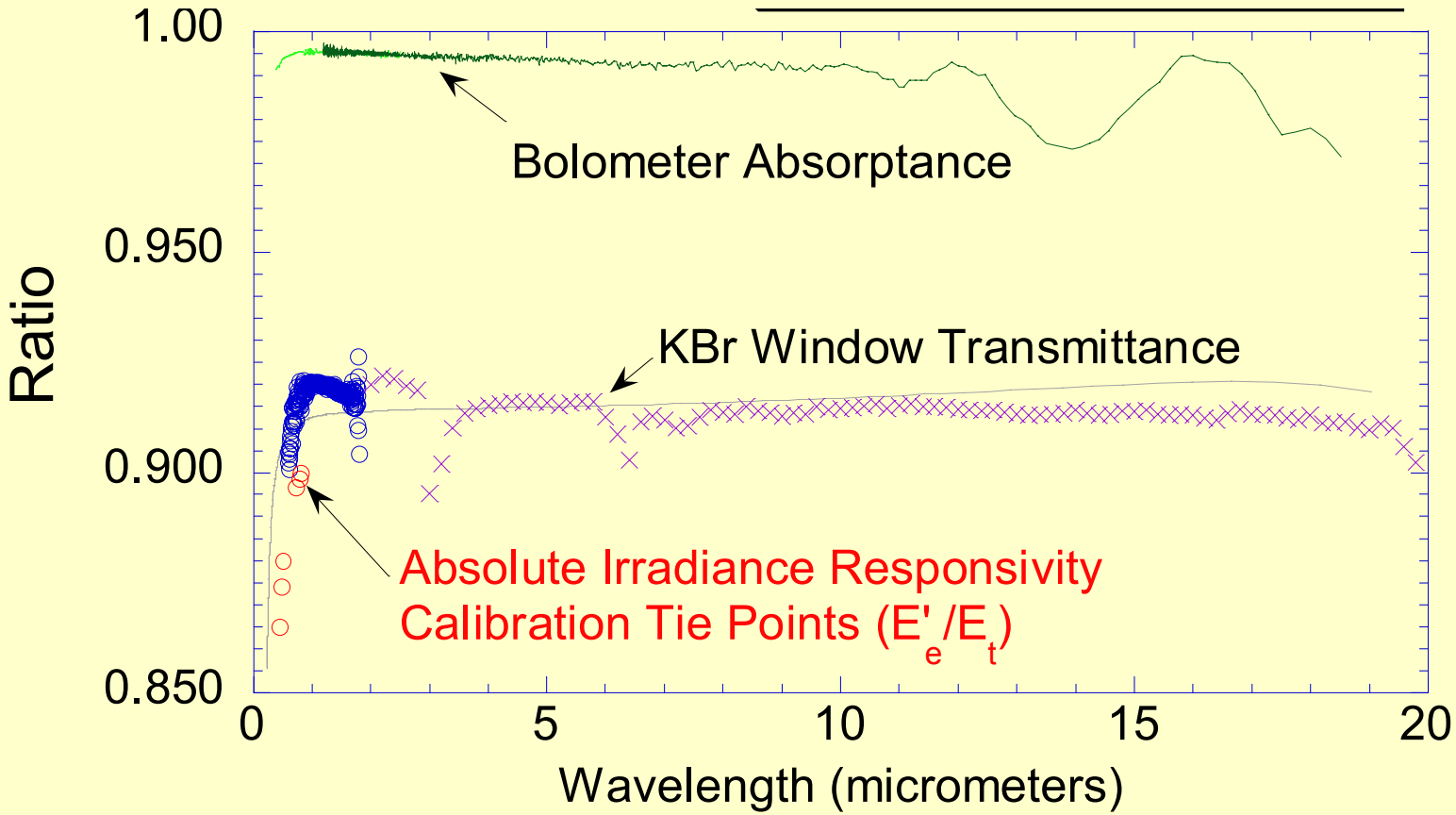


ESB Temperature Signal (15 Hz)

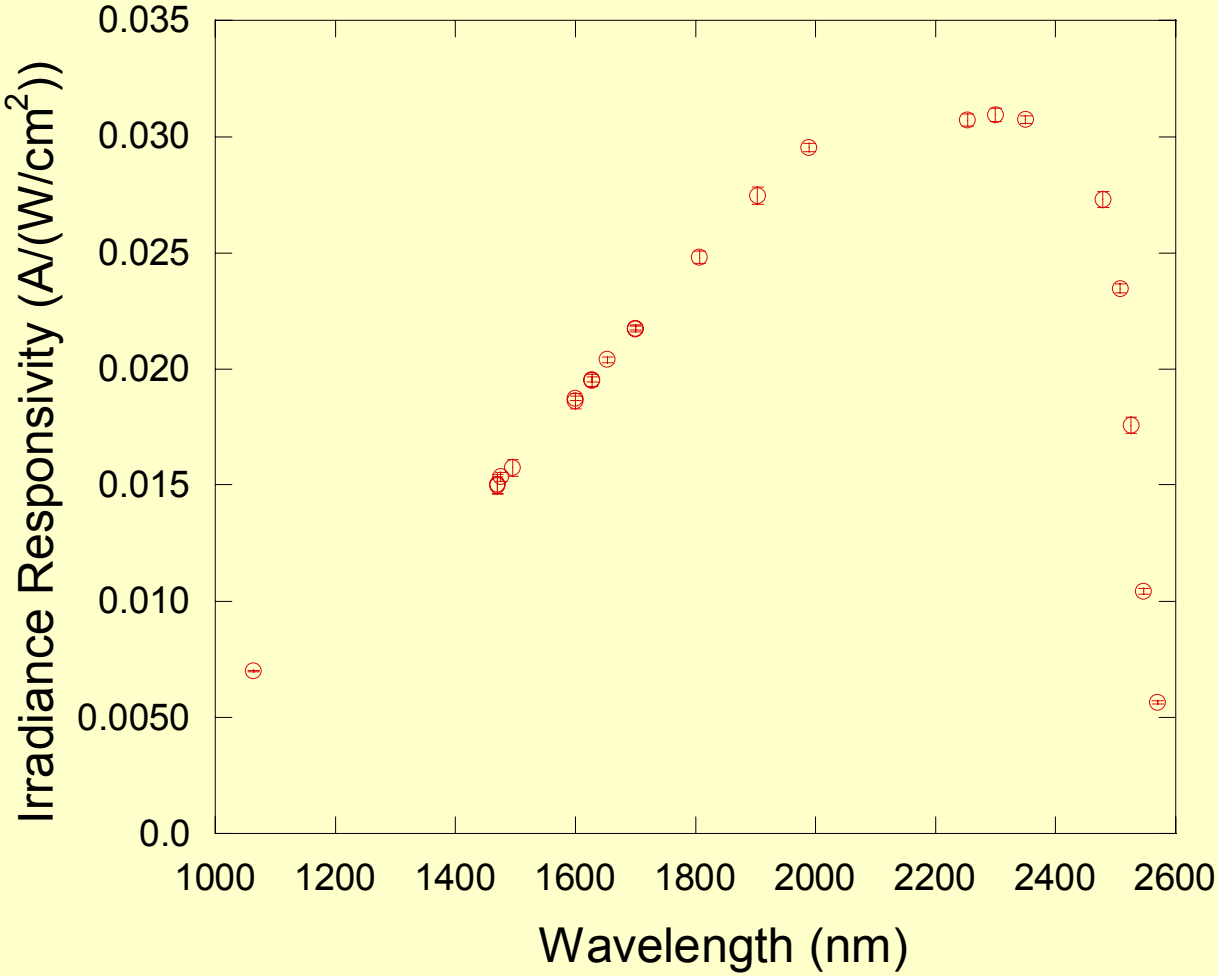


ESB Scale Realization #1

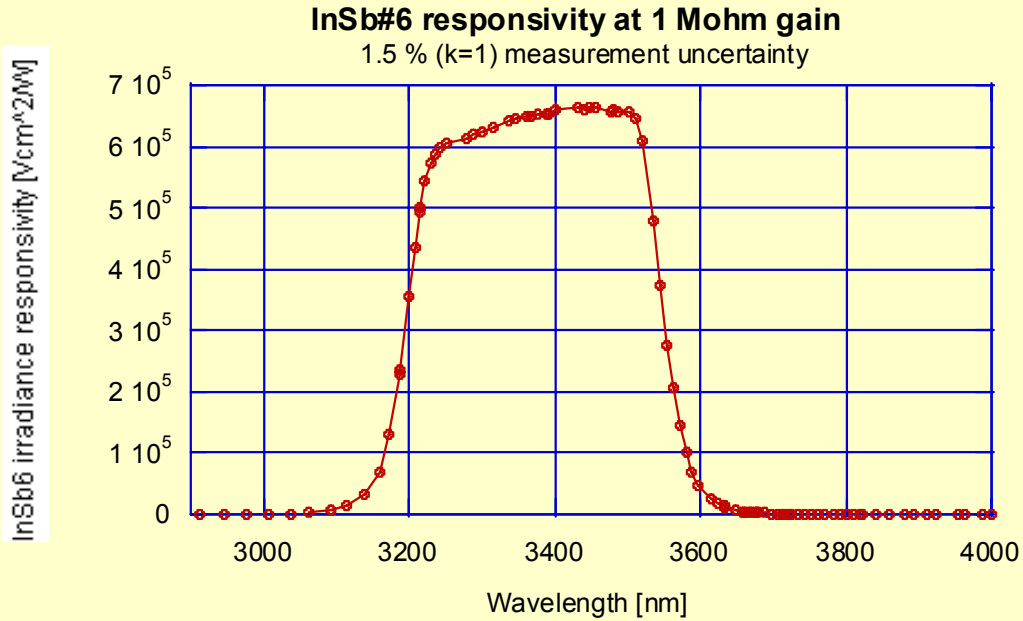
- ESB was calibrated in irradiance mode at SIRCUS: Gives Absolute Tie Points
- Spectral dependence is from Bolometer Absorptance and Window Transmittance



Extended-InGaAs Working Standard as calibrated against ESB at SIRCUS-IR

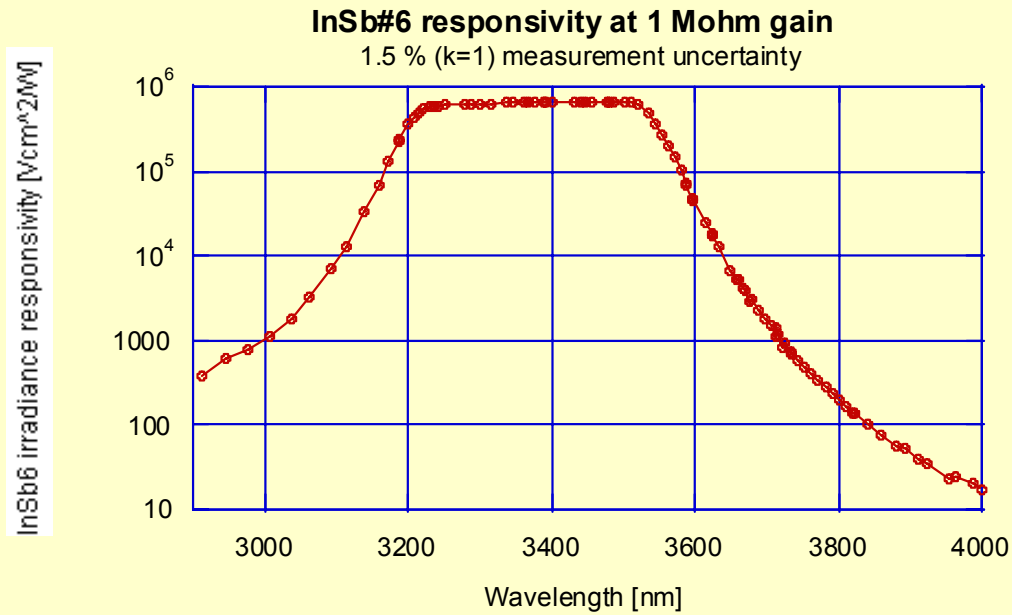


Absolute Spectral Responsivity of an InSb Radiometer

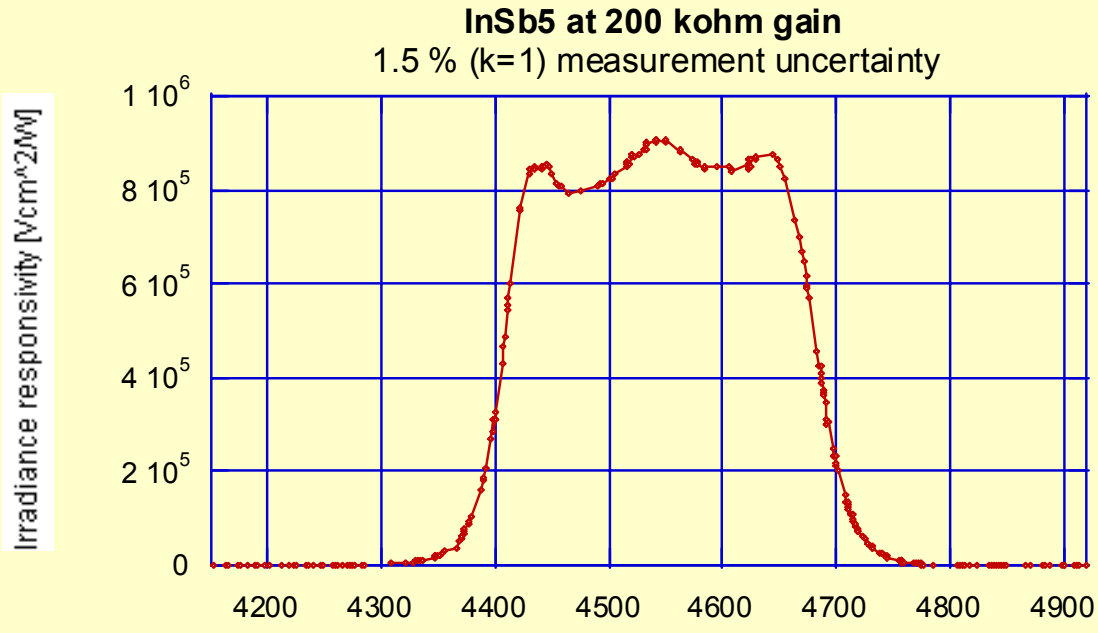


Linear Scale

Log Scale

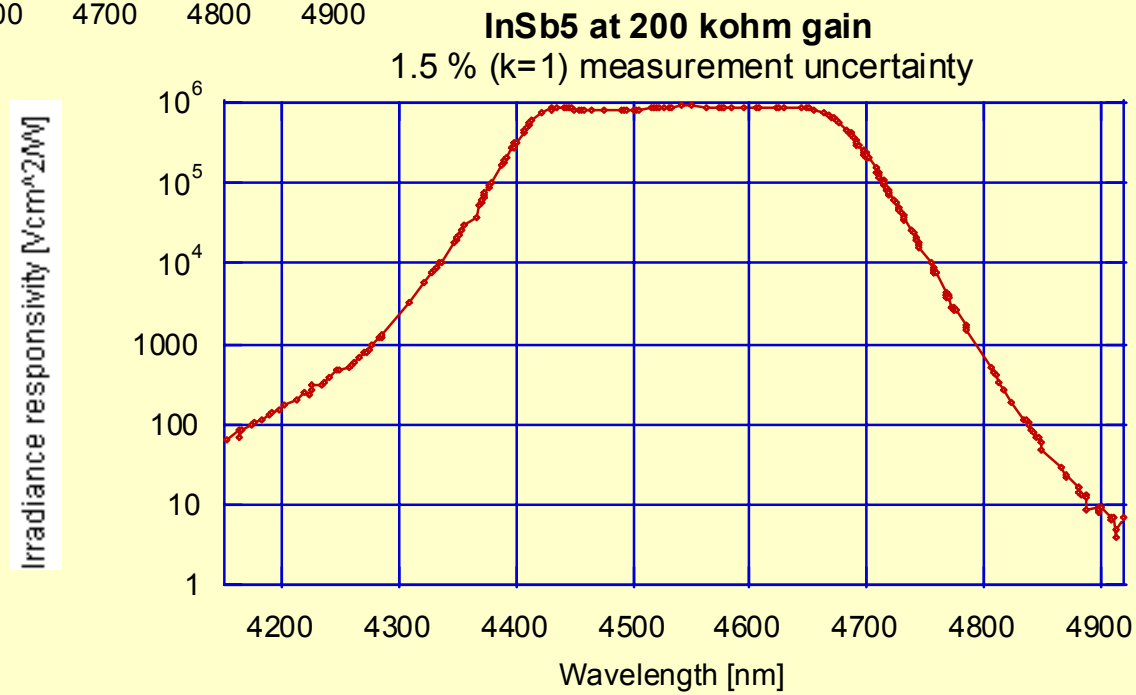


Another InSb Radiometer Calibrated at IR SIRCUS



Linear Scale

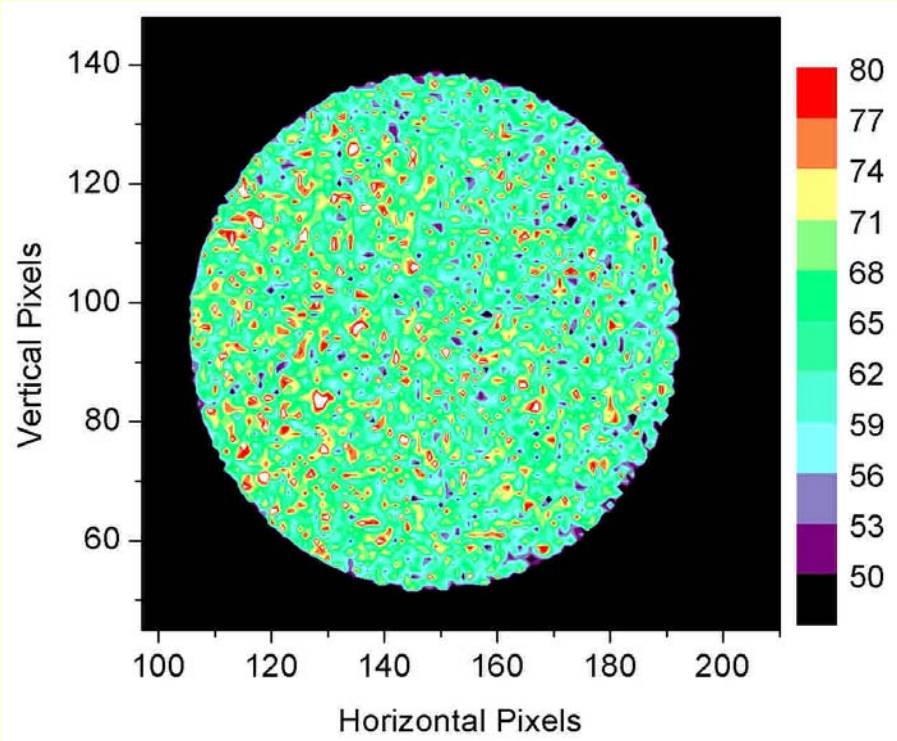
Log Scale



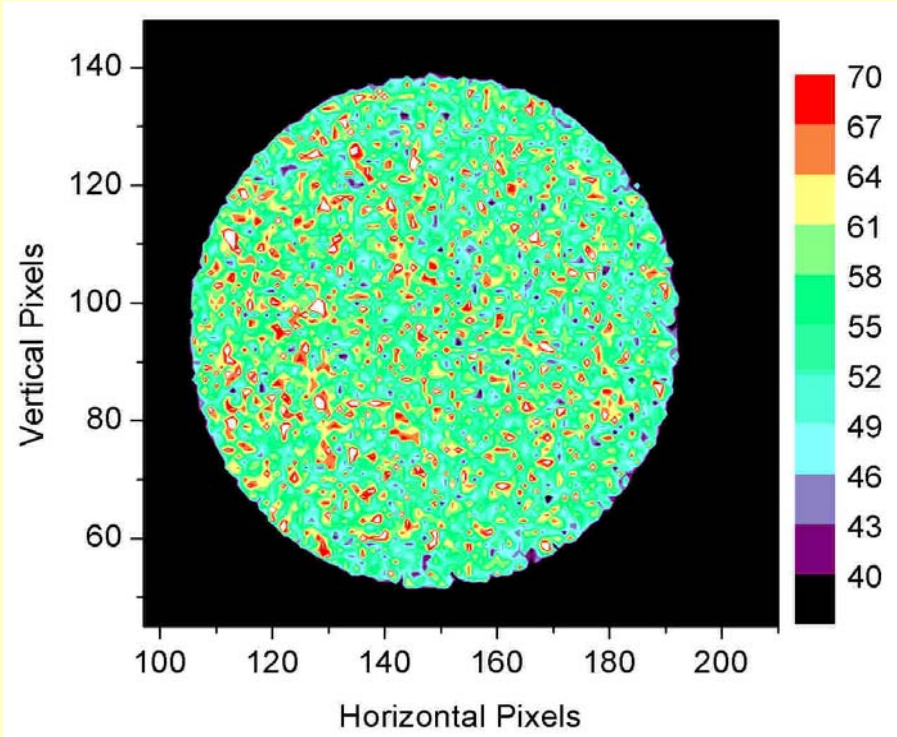
Gold-sphere Exit Aperture Images Using 320 × 240 Microbolometer Array Camera at 10.6 μm

- Color maps are of raw counts with laser minus raw counts w/o laser
- We believe that laser speckle gives the non-uniformity seen.

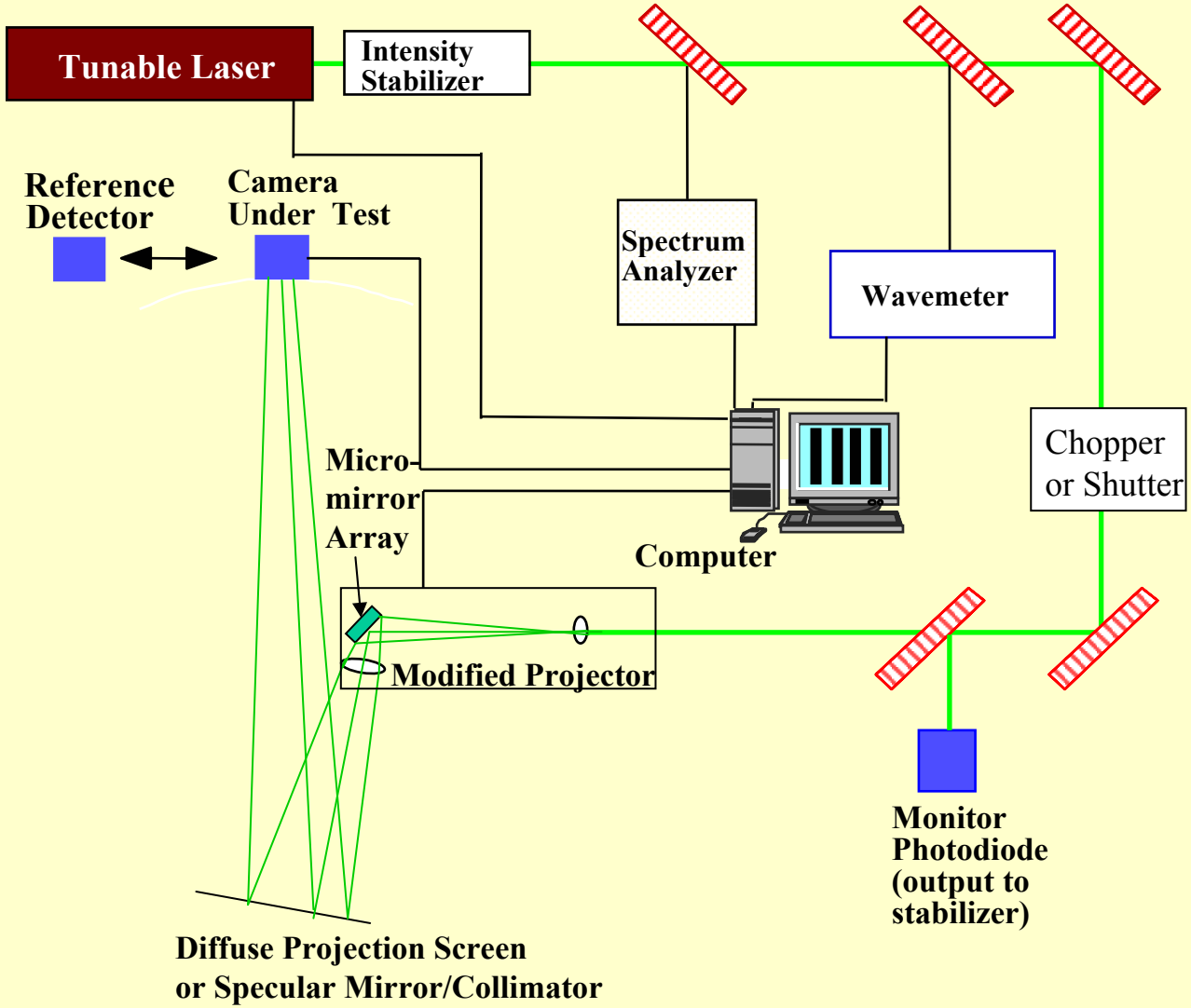
100 Hz Wobbly Mirror



200 Hz Wobbly Mirror



Laser-based PIXSIR: PIXel Spectral Irradiance and Radiance Responsivity: A laser-illuminated Micro-mirror array projecting tunable monochromatic IR scenes



Use of SIRCUS to Characterize Spectroradiometers?

- Steve Brown, Carol Johnson, et al. have pioneered this in the visible/NIR for spectrographs and spectrometers (see poster for one example).

To what extent can IR-SIRCUS be used to characterize and calibrate a Fourier Transform Spectroradiometer?

- We plan to answer this in the future…

Conclusion

The role of NIST:

•NIST is developing a unique facility: SIRCUS and IR-SIRCUS.

•NIST will continue to refine the technique and demonstrate the many advantages of this technique compared to traditional approaches.

•NIST will perform characterizations and calibrations for customers.

•Other calibration facilities may build their own versions in the future.

•Traceability to NIST would then be through irradiance responsivity of irradiance reference detectors.